

BEYOND EINSTEIN: From the Big Bang to Black Holes



Constellation

The Constellation X-Ray Mission

►► BEPAC Update

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FST Meeting
GSFC



National Academy Review

NASA and DOE funded National Academy of Science study *NASA's Beyond Einstein Program: An Architecture for Implementation*

Beyond Einstein Program Assessment Committee (BEPAC) given the following charge:

1. Assess the five proposed Beyond Einstein missions (Constellation-X, Laser Interferometer Space Antenna, Joint Dark Energy Mission, Inflation Probe, and Black Hole Finder probe) and recommend which of these five should be developed and launched first, using a funding wedge that is expected to begin in FY 2009. The criteria for these assessments include:
 - a. Potential scientific impact within the context of other existing and planned space-based and ground-based missions; and
 - b. Realism of preliminary technology and management plans, and cost estimates.
2. Assess the Beyond Einstein missions sufficiently so that they can act as input for any future decisions by NASA or the next Astronomy and Astrophysics Decadal Survey on the ordering of the remaining missions. This second task element will assist NASA in its investment strategy for future technology development within the Beyond Einstein Program prior to the results of the Decadal Survey.

Deadline for report September 8, 2007 (so as to impact FY 2009 budget)

Membership of BEPAC

Charles Kennel (UCSD) *Co-chair*

Joe Rothenburg (USN) *Co-chair*

Eric Adelburger (U. Washington)

Bill Adkins (LLC)

Tom Appelquist (Yale)

Jim Barrowman (Consultant)

David Bearden (Aerospace Corp)

Mark Devlin (U. Pennsylvania)

Joseph Fuller (Futron Corp)

Karl Gebhardt (U. Texas)

Bill Gibson (SWRI)

Fiona Harrison (CalTech)

Andrew Lankford (UC Irvine)

Dennis McCarthy (Consultant)

Stephan Meyer (U. Chicago)

Joel Primack (UCSC)

Lisa Randall (Harvard)

Craig Sarazin (U. Virginia)

James Ulvestad (NRAO)

Clifford Will (Washington Univ.)

Michael Witherell (UCSB)

Edward Wright (UCLA)

Blue = Technical, Black = science

Science Membership of BEPAC

Charles Kennel (UCSD) *Co-chair*

- Ex-Scripps Director, Ex-NASA AA for Earth science, astronomy degrees

Eric Adelburger (U. Washington)

- gravitational physics and nuclear astrophysics

Tom Appelquist (Yale)

- theory of elementary particles, the strong interactions and electroweak unification

Mark Devlin (U. Pennsylvania)

- CMB experimentalist, NASA balloons

Karl Gebhardt (U. Texas)

- central regions of galaxies and the search for dark energy using baryonic acoustic oscillations

Fiona Harrison (CalTech)

- experimental and observational high-energy astrophysics

Andrew Lankford (UC Irvine)

- elementary particle physics, particle and radiation detectors

Stephan Meyer (U. Chicago)

- CMB and WMAP team member, SPT

Joel Primack (UCSC)

- relativistic quantum field theory, Dark Matter, cosmology, particle astrophysics,

Lisa Randall (Harvard)

- elementary particles and fundamental forces, extra dimensions of space

Craig Sarazin (U. Virginia)

- interstellar medium, clusters of galaxies, x-ray emission, and extragalactic astronomy

James Ulvestad (NRAO)

- NRAO, AGN, jets

Clifford Will (Washington Univ.)

- gravitational radiation, black holes, cosmology, and tests of general relativity

Michael Withereil (UCSB)

- experimental particle physics and a former director of Fermilab

Edward Wright (UCLA)

- infrared astronomy and cosmology, especially CMB

BEPAC Activities

- First meeting Nov 6, 7, 8 at Keck Center in Washington, DC
 - Day 1: Science review talks (M. Turner - Q2C, J. Lykken - Dark Energy, M. Kamionkowski - inflation, S. Hughes - Black Holes, C. Reynolds - Black Holes)
 - Day 2: 11 Mission talks (LISA, Con-X, EXIST, CASTER, SNAP, DESTINY, ADEPT, EPIC, EPIC, CMBPol, and CIP)
- Next meeting Jan 30, 31, Feb 1 at Beckman Center, Irvine, Ca
 - Two more meetings expected (April and June?)
- Up to four Town Hall meetings across the country

See web site for presentations and up to the minute information

<http://www7.nationalacademies.org/ssb/BeyondEinsteinPublic.html>

CONSTELLATION-X SCIENCE OBJECTIVES

Black Holes

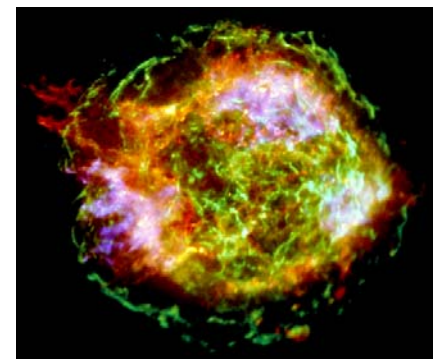
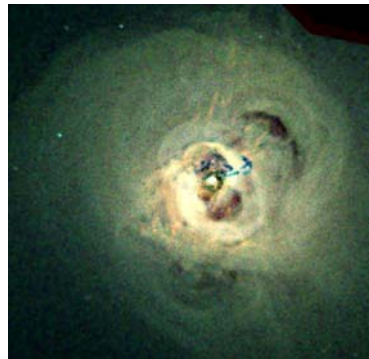
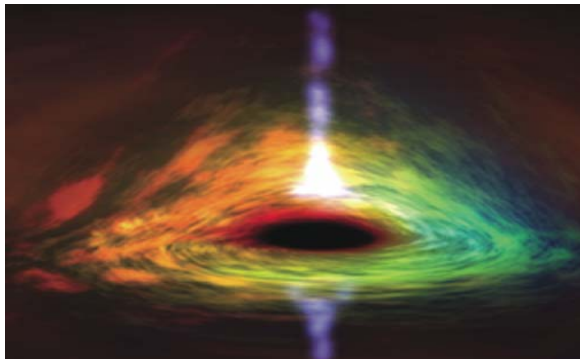
- Observe matter spiraling into Black Holes to test the predictions of strong field General Relativity
- Study distant/faint sources to trace the evolution of Black Holes with cosmic time

Dark Matter and Dark Energy

- Use Galaxy Clusters to trace dark matter and as probes for amount and evolution of dark energy

Cycles of Matter and Energy

- Study behavior of matter at extreme densities & magnetic fields using Neutron Stars
- Measure production of heavy elements in Supernovae
- Investigate the influence of Black Holes on galaxy formation
- Search for the hot missing baryons in the Cosmic Web



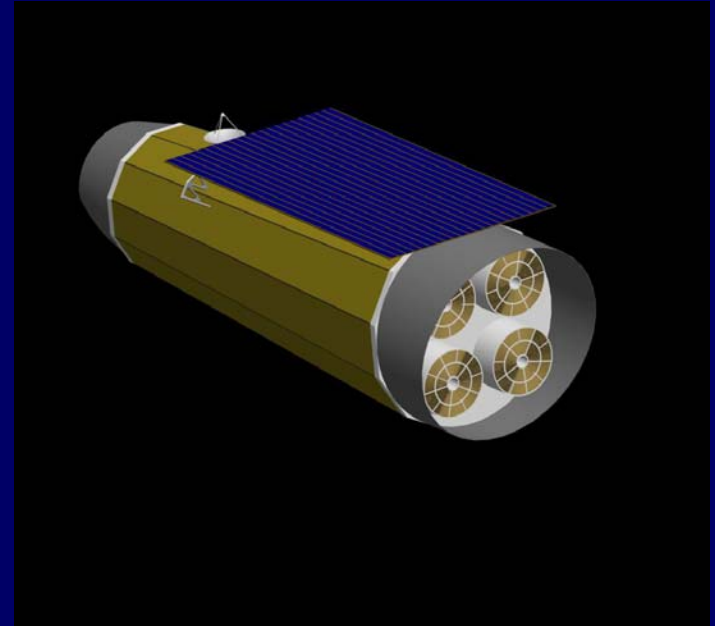
Constellation-X Addresses 8 of 11 Quarks to Cosmos Questions

Did Einstein have the last word on gravity?	Black Holes	◆◆◆
What is the nature of the Dark Energy?	Galaxy Clusters	◆◆◆
What is the Dark Matter?	Galaxy Clusters	◆◆
Are there new states of matter at exceedingly high density and temperature?	Neutron Stars	◆◆◆
How were the elements from iron to uranium made?	Supernova Remnants Galaxy Clusters	◆
How do cosmic accelerators work and what are they accelerating?	Black Holes Supernova Remnants	◆◆
Is a new theory of matter and light needed at the highest energies?	Neutron Stars (10^{14}G)	◆
What are the masses of the neutrinos, and how have they shaped the evolution of the universe?	Galaxy Clusters	◆

Fundamental results ◆◆◆

Major contribution ◆◆

Discovery space ◆



Constellation-X is low risk and ready to proceed

- High throughput, high spectral resolution X-ray spectroscopy is essential to accomplish Beyond Einstein science
- The technology development is proceeding on schedule and is on track to achieve the required Technology Readiness Level (TRL6) by 2009
- No technology breakthroughs or test flights required
- The mission utilizes extensions of flight proven technology — the Chandra and Suzaku X-ray optics and Suzaku microcalorimeter, standard spacecraft, operations and data analysis
- Experienced science and management team comprised of world leaders in field — have built and flown many successful instruments and missions

Constellation-X starts Beyond Einstein with a Bang!

- High science per dollar — Mission addresses 8 of the 11 Quarks to Cosmos Questions, with the focus on Black Holes as tests of GR, Dark Matter and Dark Energy, and matter under extreme conditions
- Opens the window of X-ray spectroscopy — a powerful tool transforming X-ray Astronomy into X-ray Astrophysics
- Science success guaranteed — hundreds of thousands of known targets with measured count rates and directly observable signals
- Engages a large community — Astrophysicists, Cosmologists, and Physicists through an open General Observer Program

<http://constellation.gsfc.nasa.gov>